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Rheology of High-Melt-Strength Polypropylene for Additive Manufacturing

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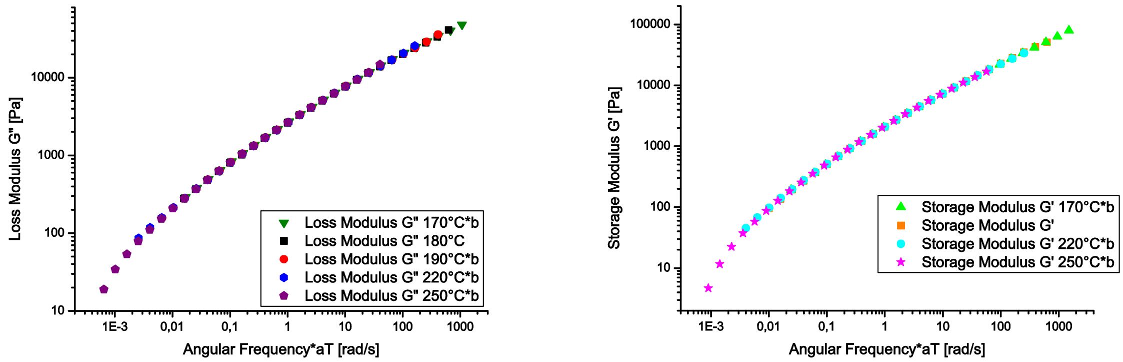
Table of contents

Rheological measurements of high-melt-strength polypropylene (HMS-PP) were used to generate master curves describing the shear-dependent viscosity in comparison to acrylonitrile butadiene styrene (ABS). Hereafter, the material was used in a fused deposition modeling (FDM) additive manufacturing (AM) process.



Loss modulus and storage modulus for HMS-PP at 190 °C

ABSTRACT

Acrylonitrile butadiene styrene (ABS) is a widely used material for additive manufacturing (AM) fused deposition modeling (FDM). The rheological properties of high-melt-strength polypropylene (HMS-PP) were compared to commercially available ABS 250 filament to study the possibility of using this material for FDM. The aim of this research contribution was to generate a full description of the viscosity in a plate-to-plate rheometer. Moreover, the materials were used in an FDM process focusing on the investigation of possible improvements of HMS-PP over ABS. The latter material showed specific disadvantages in terms of thermal stability. In particular, the storage modulus G’, loss modulus G”, and complex viscosity were measured at temperatures between 170 °C and 250 °C and brought to superimpose using the time-temperature superposition method to create master curves of the two materials. The comparison of the time sweep allowed the conclusion that HMS-PP is more stable by showing less variation during the studied period of two hours. The master curves of ABS concluded that data measured at 250°C deviates significantly from the curves derived from measurements at lower temperatures. In particular, the storage modulus and complex viscosity data of ABS 250 could not be used to enlarge the master curve values. HMS-PP showed a more stable behavior at the studied temperatures, and all data points were suitable to create the master curves. Practical studies to determine adapted extrusion parameters for HMS-PP were carried out using an FDM machine. ABS was extruded through a J-Head extruder with

0.4 mm nozzle-diameter and 243 °C extrusion temperature. The extrusion was performed in a vertical direction with gravitational forces pointing in the extrusion direction. The fused filament depended on the extrusion speed and diameter, resulting in an optimal printing speed of 60 to 80 mm/min. The HMS-PP granule was extruded into a filament of 1.75 mm diameter and then extruded through a J-Head and E3D with 0.4 mm nozzle-diameter and 200 to 240 °C. A comparison of the primary material with the printed material showed negligible changes in the measurement curves which might lead to the conclusion that the degradation of HMS-PP during the FDM process is as low as the degradation of ABS.

Keywords: Additive Manufacturing Technology, ABS, HMS-PP, Rheology

Reference (Not more than 5, please follow the below reference style if any).

1. Carneiro, O. S., A. F. Silva, R. Gomes, *Materials & Design 83*, 768-776, **2015**